NACA DUCT RATIONALE FOR BUB STREAMLINER

March 15, 2007 – R. Keller

Turbocharger inlet diameter is 4 inches.
Turbo inlet area is 12.56 in^2.
Turbocharger output is 85 lb/min @ 7000 ft altitude.

Air density @ 7000 ft = .0575 lb/ft^3
Air density @ 4000 ft = .0644 lb/ft^3 (Bonneville Salt Flats)

Turbocharger output is (.0644/.0575) x 85 lb/min @ 7000 ft = 95.2 lb/min @ 4000 ft
95.2 lb/min ÷ .0644 lb/ft^3 = 1478 ft^3/min turbocharger output
1478 ft^3/min ÷ 60 sec/min = 24.6 ft^3/sec
24.6 ft^3/sec x 12 in^3/ft^3 = 24.6 x 1728 = 42,509 in^3/sec turbocharger output/desired input air supply

Design NACA submerged inlet duct for optimum ram air effect at nominal maximum vehicle velocity of 400 mi/hr. NACA duct ram-recovery ratio ≥0.9 (≥90%) for inlet velocity ratios between 0.6 and 1.5, at Mach numbers from 0.30 to 0.875. Optimum inlet velocity ratio is ≈ 0.70, i.e., *duct inlet velocity = 0.7 x vehicle (air stream) velocity at 400 mi/hr*.

400 mi/hr = 587 ft/sec = 7044 in/sec

At 400 mi/hr (7044 in/sec), with a design ram-air recovery ratio of 0.9 at the optimum inlet velocity ratio of 0.7:
therefore, 42,509 in^3/sec ÷ 0.9 ratio = 47,232 in^3/sec design duct inlet flow @ 400 mi/hr @ 4000 ft.
47,232 in^3/sec ÷ 7044 in/sec = 6.71 in^2 inlet duct area at a velocity ratio of 1.0.
6.71 in^2 ÷ 0.7 = 9.58 in^2 inlet duct area @ .07 inlet velocity ratio at 400 mi/hr @ 4000 ft.

Inlet duct dimensions of 1.5625 in x 6.25 in = 9.77 in^2 inlet area. This would be the ideal NACA inlet duct area for the BUB streamliner at 400 mi/hr located in a region of thin boundary layer.

The effective velocity range of 90% ram-recovery ratio for this size NACA duct would be for inlet velocity ratios between 0.6 and 1.5. The inlet velocity of this duct is 4930 in/sec at maximum turbocharger output.
4930 in/sec ÷ 1.5 = 3287 in/sec = 274 ft/sec = 187 mi/hr
4930 in/sec ÷ 0.6 = 8217 in/sec = 685 ft/sec = 467 mi/hr.
Therefore, the NACA duct will provide ram air at an efficiency of 90% or greater at velocities between 187 mi/hr and 467 mi/hr. This should allow sufficient air intake with low drag throughout the operating range of the BUB streamliner.